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Production of indigenous alcoholic beverages in a rural village of Tanzania

Ryosuke Kubo

Abstract

In this study, the production techniques of indigenous alcoholic beverages in a rural village in Tanzania were investigated. In the village, three different kinds of alcoholic beverages were produced: a maize turbid beer (*komoni*), a straw beer (*kimpumu*) and a hybrid straw beer (*kiambule*). In the course of the production of these three alcoholic beverages, two different kinds of porridge, a fermented porridge (*nyambo*) as a source of yeasts and a sweet porridge (*kikonde*) as a source of saccharides, were produced. These porridges were mixed at the end of the production process. The pH value of fermented porridge was kept below 4 during its preparation. This was effective in preventing contamination of the porridge by harmful bacteria and in stabilizing the growth of the yeasts. Sweet porridge was heated in the range of 50–70 °C and this enhanced the saccharification of the starch in the raw materials. The starting materials of these alcoholic beverages were finger millet and maize. Germinated finger millet, which has a high amylase activity compared with other cereals, was used as an amylase source in each of the alcoholic beverage production processes. Various techniques to enhance and stabilize the quality of the indigenous alcoholic beverages are described.

Keywords: brewing; alcoholic beverage; Africa; food culture; straw beer; finger millet

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Introduction

In the past, humans produced various kinds of traditional, local and indigenous alcoholic beverages (hereafter, indigenous alcoholic beverage) worldwide that were manufactured and consumed by local communities. However, nowadays, alcoholic beverages are industrially produced and commercially available in most developed countries. Although commercial alcoholic beverages are dominant in developed countries, indigenous alcoholic beverages are still being produced and consumed, and dominate most of the alcohol consumption, in sub-Saharan Africa. In east Africa, the consumption of indigenous alcoholic beverages accounts for about 80% of the entire consumption (1). In some of those areas, alcoholic beverages constitute payment for labour and serve as an important cash income for women (2,3). Additionally, in those areas, alcoholic beverages are also consumed as a source of calories, proteins and vitamin B (4).

Tanzania, which is in East Africa, where indigenous alcoholic beverages are still a dominant part of the entire alcohol consumption, is the third largest beer-consuming country in Africa (including indigenous alcoholic beverages) (5). At least 12 kinds of indigenous alcoholic beverages (6) are currently produced in Tanzania. The country is probably one of the biggest indigenous alcoholic producing and -consuming countries in sub-Saharan Africa.

In some rural areas of Tanzania, where a self-sufficient food habit has been maintained, people obtain their essential nutrients from a limited variety of food using various food-processing techniques, including alcoholic beverage production. Therefore, knowledge of the proper production techniques to produce the indigenous alcoholic beverages is necessary. Moreover, since alcoholic beverages are used as compensation for labour, a source of cash income and a nourishment source, the quality of the alcoholic beverages directly affects the life of both the producers and consumers. However, it is difficult to assess the efficiency of the indigenous alcoholic beverage production techniques, because the processes are complicated and the details unclear. In this study, the production techniques of indigenous alcoholic beverages in a rural village in Tanzania were investigated. The objective of the present study was to clarify the details and efficiency of their particular indigenous alcoholic beverage production process.

Materials and methods

Field

Field research, including interviews and measurements, was carried out in a

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small village named *Bupigu* (1153 inhabitants divided into 305 households) located in the middle-Southern part of Tanzania, 33°20′ E longitude and 9°29′ S latitude. In this region, the dry season is from May to November, the heavy rain season is from December to March, and the light rain season is from March to April. The altitude and the annual rainfall are 1100–1700m and 1000–1150mm, respectively (7). The field research was carried out in September to November and in June. Observations, interviews, and the measurement of parameters of the indigenous alcoholic beverage production were carried out in the village. Details of indigenous alcoholic beverage production to clarify the details of the production technique, the weight and volume of the materials used in each step were measured. The change in the temperature of the samples during heating was measured using an infrared thermometer (826-T3; Testo, Kanagawa, Japan).

Measurement of ethanol, glucose and lactic acid concentration, and pH of indigenous alcoholic beverages

Ethanol, glucose and lactic acid concentrations and the pH of the samples were measured in the village as described below. To measure the ethanol, glucose and lactic acid concentrations, the samples were centrifuged at 2000 rpm for 3 min (hand powered centrifuge, AS ONE Corp., Osaka, Japan). The samples were diluted with ion-exchanged water before centrifugation as needed. The supernatants obtained were filtered through Qualitative Filter Paper no. 2 (Toyo Roshi Kaisya Ltd., Tokyo, Japan) and then membrane-filtered (0.45 μm; Millex-HV Filter Unit, Millipore Corp., Cork, Ireland). Filtrates were used for the assay of ethanol, glucose and lactic acid concentrations.

The glucose and lactic acid concentrations of the filtrates were measured in the field using a portable glucose measuring device (Glutest Ace®; Arkley, Kyoto, Japan) and a lactic acid-measuring device (Lactate Pro®; Arkley, Kyoto, Japan), respectively. Before the measurements, the filtrates were diluted using a 1.82M sodium phosphate buffer, pH7.4. A 20μL sample was used for the measurements.

To determine the ethanol concentration, the refractive index value of the samples was measured using an Abbe refractometer (FHR-1; TGK, Tokyo, Japan). As the refractive index value of the samples reflects the ethanol concentration, the ethanol concentration could be calculated by the observed refractive index values using standard curves from known concentrations of ethanol. The pH values were measured using a pH meter (B-212; Horiba Ltd, Kyoto, Japan).

All of the treatments and experiments were carried out in the village using the

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instruments and reagents that were brought in, as described above.

Results

The population of *Bupigu* village produces three kinds of indigenous alcoholic beverages (*pombe*): *komoni* is a turbid beer, *kimpumu* is a straw beer and *kiambule* is a hybrid straw beer. The turbid beer originates from germinated maize (*kimea wa mahindi*) and germinated finger millet (*kimea wa ulezi*). The straw beer is obtained from germinated finger millet, and the hybrid straw beer is made with germinated maize and germinated finger millet, like the turbid beer.

Turbid beer is consumed directly without dilution, while both straw beer and hybrid straw beer are diluted with hot water (1:1) before drinking. On adding hot water, the turbid suspensions of straw and hybrid straw beer separate into three parts: the floating husk part (upper part), the clear part (middle part) and the precipitate part (lower part). A long straw is inserted into the clear part, and that part is drunk through the straw (Fig. A1).

To prepare each indigenous alcoholic beverage (i.e. turbid beer, straw beer and hybrid straw beer), the producers first prepared two kinds of porridge, a ‘fermented porridge’ (*nyambo*) and ‘sweet porridge’ (*kikonde*), and later mixed them. Although all the three different beverages were produced with both types of porridge, the preparation methods of the porridges were distinct. Therefore, the details of the manufacturing process of the ‘fermented porridge’ and ‘sweet porridge’ for each alcoholic beverage are described in detail for each alcoholic beverage.

Preparation of germinated cereals

The starting materials of the indigenous alcoholic beverages, germinated maize and finger millet, were prepared as follows. Maize and finger millet seeds were soaked in water for one day, and the swollen seeds were put into a nylon bag for 2 days. Then, sprouts of maize and finger millet were spread on the floor of the room, sprayed and covered with a plastic sheet for one day. After that, sprouts of maize and finger millet were sun-dried for 2–3days, and then turned to flour by pulverizing (Fig. A2). The flour of the cereals was prepared in similar ways in the different households.

Turbid beer production

‘Fermented porridge’ of turbid beer was prepared as follows (Fig. 1). Maize husks (3.33 kg) were put into a plastic pot and soaked in water (10.6 L) for 3 days at room temperature. After soaking, the slurry was transferred to a clay pot, and 11.9 L of water

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was added. The diluted slurry was heated for 9 h while stirring occasionally, and then the pot was placed outside to cool for ~3 h (Fig. 2A). Next, the slurry was transferred to a plastic pot and 500 g of the germinated maize flour was added, mixed well and left for 2 days.

The germinated maize flour was obtained from old maize seeds that had been stored for more than a year after harvest. According to the villagers, fresh maize seeds do not guarantee sufficient alcohol fermentation, and, therefore, the use of aged maize is necessary. During the storage of maize seeds, the yeast in the atmosphere probably adheres to the surface of the seeds. Therefore, by adding maize seeds to the slurry, the yeasts may have been inoculated into the slurry thus leading to an alcohol fermentation. Therefore, aged maize is probably the source of the yeast for the fermentation.

During the 2 days, the pot containing the slurry was occasionally moved outside to the sunshine, during which time the temperature of the slurry increased to ~30 °C. The warm temperature enhanced the growth and proliferation of yeast in the slurry. After 2 days, 390 g of the germinated finger millet flour was added, the mix was left for about 7 h, and then 10.5 L of a different slurry (the ‘sweet porridge’ of turbid beer described below) was added to give the ‘fermented porridge’ of turbid beer. The process to produce the ‘fermented porridge’ of turbid beer lasted 6 days.

Changes in the concentrations of glucose and lactic acid and pH during the production of ‘fermented porridge’ are shown in Fig. 3. The glucose concentration was less than 1mM throughout the manufacturing steps. The lactic acid concentration was low until day 5, and increased to 9.6mM on the last day, whereas pH decreased to <5 on day 2. The decrease in the pH indicated that the lactic fermentation had started on day 1 and lactic acid was produced in sufficient amounts to lower the pH to 5, indicating that starch was hydrolysed and the glucose produced was consumed for lactic fermentation. However, it was assumed that the lactic acid concentration was <0.80mM until day 5 and could not be detected by the lactic acid measuring device. A low pH is favourable for yeast proliferation and suppresses the growth of contaminating bacteria, with the exception of lactic bacteria, meaning that suitable conditions for alcohol fermentation by yeast and food safety are achieved by the preceding lactic fermentation. The ‘fermented porridge’ of turbid beer obtained on the final day was a viscous liquid with no sweetness.

On day 3 of the production of ‘fermented porridge’, the slurry was ready after boiling for 9 h, after which it was cooled for 3 h at ambient temperature. During this period, the temperature of the ‘fermented porridge’ of the turbid beer increased to 95 °C, and it was maintained at 80–90 °C for 8 h, and then decreased by cooling (Fig. 2A).

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This temperature treatment ensured that the starch included in the starting materials was completely gelatinized and that contaminating bacteria in the slurry were killed. After heating, the germinated maize and finger millet flour were added successively. Since aged maize was chosen for this step, the addition of the flour of the germinated cereals was accompanied by the inoculation of yeasts and lactic bacteria, which could grow well in the presence of appropriate amounts of nutrients. In other words, the 'fermented porridge' of turbid beer appeared to be the source of yeast for the alcohol fermentation in the following step.

'Sweet porridge' of turbid beer was prepared as follows. The geminated maize flour (2.31 kg), germinated finger millet flour (1.40 kg) and water (59.9 L) were mixed in a large vessel and heated for 5 h with occasional stirring. The temperature of the slurry was maintained at around 50–70 °C for 5–6 h (Fig. 2A). In this range of temperature, the amylase activity of the finger millet was stable and maximized (8). Therefore, the starch in the starting materials was hydrolysed effectively during the heating process. After heating, the slurry was transferred into several containers and cooled for 5 h. 'Sweet porridge' of turbid beer contained large amounts of glucose (Table 1) and other saccharides. However, the lactic acid concentration was <0.80mM, meaning that no lactic fermentation occurred, and the pH was not as low as that of the 'fermented porridge'. 'Sweet porridge' of turbid beer is sometimes used as a nutritious food for children, because it contains large amounts of saccharides and is easily digested. When the 'sweet porridge' of turbid beer is used as a nutritious food, it is called *togwa*, which is the name of the non-alcoholic saccharified beverage widespread in Tanzania (9). *Togwa* is also drunk as a nutritious food because the carbohydrates of various molecular sizes contained in the beverage supply energy quickly and continuously, enabling people to perform hard and long-term labour work in the fields (10).

Finally, 'fermented porridge' and 'sweet porridge' were mixed together and incubated for 12 h. The obtained turbid beer (*komoni*) was filtered using a nylon bag to give a translucent filtrate. The analysis of this beer is given in Table 1.

Straw beer production

The production of straw beer is shown in Fig. 4. 'Fermented porridge' and 'sweet porridge' of straw beer were prepared using only germinated finger millet as a starting material. The 'fermented porridge' of the straw beer was prepared as follows. The germinated finger millet flour (352 g) was put into a clay pot (Fig. A3) and boiling water (4.91 L, 96 °C) was added. Then, the slurry was stirred vigorously until it became smooth. After stirring, the temperature of the slurry decreased from 60 to 40 °C with

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time (Fig. 2B). In this temperature range, the amylase in finger millet is stable and shows high enzyme activity (8, 11). The glucose concentration at the beginning of the preparation of the ‘fermented porridge’ of straw beer was much higher than that of the turbid beer and hybrid straw beer (Fig. 3). After the temperature of the slurry was reduced, the mixture was left for 6 days. During this period, the pot containing the slurry was kept in the kitchen, where the temperature of the slurry increased to 30 °C. This warming enhanced the growth and proliferation of the yeast in the slurry. After 6 days, a ‘fermented porridge’ of straw beer was obtained. The glucose concentration was <1.1mM, the lactic acid concentration was 4.0mM and the pH was 3.4 (Table 1).

The ‘sweet porridge’ of the straw beer was prepared as follows. The germinated finger millet flour (1.55 kg) was put into a clay pot with boiling water (10.5 L, 88 °C). By vigorously stirring, the mixture became smooth, and the paste obtained was spread on a plastic sheet to cool for 3 h. This was the ‘sweet porridge’ of the straw beer. The temperature of the paste on the plastic sheet was maintained at around 40–60 °C during cooling (Fig. 2B). During this cooling time, glucose is thought to be efficiently produced by the action of the amylases in the germinated finger millet. The glucose concentration of the ‘sweet porridge’ of the straw beer was higher than that of the turbid beer and hybrid straw beer, which resulted in a higher concentration of ethanol in the straw beer (Table 1). Similar to *togwa* from the ‘sweet porridge’ of turbid beer, the ‘sweet porridge’ of the straw beer is also drunk directly, in which case it is called *pupya*.

‘Fermented porridge’, ‘sweet porridge’ and 4.45 L of water were mixed together, and this mixture was left for 1 day. The slurry obtained was straw beer. The glucose concentration was <1. 1mM, meaning that most of the starchy materials and saccharides, including oligosaccharides and glucose, would be converted into ethanol and lactic acid by the alcohol and lactic fermentations, respectively. In the case of straw beer, both the ethanol and lactic acid concentrations were higher than those of the turbid beer and hybrid straw beer (Table 1). This result was probably the result of the high amylase activity of the germinated finger millet. A high glucose concentration in the ‘fermented porridge’ from the straw beer preparation was observed at an early stage of production and this decreased at the later stage (Fig. 3), indicating that the glucose was used for the growth and proliferation of the lactic bacteria and yeast. The glucose concentration in the ‘sweet porridge’ of the straw beer was very high (Table 1) and supplied substrate for the alcohol and lactic fermentations by the yeast and lactic bacteria. Owing to these effects, high concentrations of ethanol and lactic acid were obtained.

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Hybrid straw beer production

The ‘fermented porridge’ of hybrid straw beer was prepared as follows (Fig. 5). The germinated maize flour (4.02 kg) was put into a clay pot, 7.54 L of water was added and the mixture was left for 3 days. After 3 days, boiling water (30.0 L, 87 °C) was added and the slurry was heated for 4 h. After heating, the slurry was spread onto a plastic sheet for 3 h to cool. The temperature of the slurry during heating was maintained at around 60–70 °C (Fig. 2C). In this temperature range, the amylase in finger millet was still stable, although the amylase in maize was destroyed (11). Therefore, glucose was not produced in as large amounts in this step (Fig. 3). The heating process was necessary mainly to achieve gelatinization of the starch material. The cooled slurry was put back into the clay pot, the germinated finger millet flour (156 g) was added and the mixture was left for 2 days. After 2 days, warm water (0.57 L, 34.5 °C) was added. By adding warm water, the slurry maintained an optimum temperature for yeast growth. After 1 day, the ‘fermented porridge’ of hybrid straw beer was obtained. Changes in the lactic acid concentration and pH during the preparation of ‘fermented porridge’ of hybrid straw beer were similar to those of the turbid beer and straw beer (Fig. 3).

A ‘sweet porridge’ of hybrid straw beer was prepared as follows. The germinated finger millet flour (241 g) was put into a clay pot and boiling water (5.65 L, 93 °C) was added. Vigorous stirring rendered the mixture smooth, which was then cooled on a plastic sheet to give a ‘sweet porridge’ of hybrid straw beer. Since after the addition of the boiling water, the temperature of the slurry was maintained at around 40–60 °C for 3 h (Fig. 2C), glucose was produced efficiently by the action of the amylases contained in the germinated finger millet. The glucose concentration of the ‘sweet porridge’ of the hybrid straw beer was 29.3mM, which was lower than that of the straw beer. This might be caused by the smaller amount of germinated finger millet flour in the suspension compared with that in the straw beer (i.e. 241 g flour/ 5.65 L water for hybrid straw beer against 1.55 kg flour/10.5 L water for straw beer). In the ‘sweet porridge’ of the hybrid straw beer, no lactic acid was detected and the pH was 5.7 (Table 1).

Finally, the ‘fermented porridge’ and ‘sweet porridge’ of the hybrid straw beer were mixed and kept for 12 h to yield the hybrid straw beer. The ethanol concentration was lower than that of the turbid beer and the straw beer (Table 1). Because the ‘sweet porridge’ of the hybrid straw beer had a relatively low glucose concentration, this meant that the fermentable substrate for alcohol fermentation was lower, leading to a lower ethanol concentration.

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Discussion

In the course of the production of indigenous alcoholic beverages, various manufacturing techniques effective in stabilizing and improving the quality of the products were observed. ‘Sweet porridge’ was heated at nearly optimal temperatures for amylases to efficiently saccharify the starch in the materials. ‘Fermented porridge’ appeared to be a culture medium of yeast, while ‘sweet porridge’ was a source of saccharides for the fermentation. By mixing ‘fermented porridge’ and ‘sweet porridge’, the yeasts from the ‘fermented porridge’ grew and proliferated by consuming the saccharides contained in the ‘sweet porridge’ as nutrients. By producing the ‘fermented porridge’ first as the yeast culture source, the contamination of harmful bacteria in the ‘sweet porridge’, which is a saccharide source, was prevented. The source of yeasts in the ‘fermented porridge’ appeared to be the germinated maize in the turbid beer and finger millet flour in the hybrid straw beer. In other words, yeast adhering to the maize and finger millet seeds was probably the source of the yeast for the alcohol fermentations. After boiling the turbid beer and heating the hybrid straw beer, germinated maize and finger millet flour were added. After this step, procedures that enhanced the growth of the yeasts were carried out. In the course of turbid beer production, the slurry that was going to become the ‘fermented porridge’ of turbid beer was placed outdoors and exposed to sunshine. In the case of the ‘fermented porridge’ of the hybrid straw beer, warm water was added, and the slurry was kept at a slightly higher temperature. These techniques would enhance yeast growth. Additionally, only aged maize, which had been preserved for more than a year, allowing the yeasts in the environment to adhere to the surface of the seeds, was used to produce turbid beer. In case of the ‘fermented porridge’ of the straw beer, the source of the yeast appeared to be the clay pot or the environment itself. The villagers stated that they always used the same clay pot to produce the straw beer, and that the alcohol fermentation did not proceed well when the clay pot was changed. In the course of the production of the ‘fermented porridge’ of straw beer, some particular handling procedures that could enhance yeast growth were observed. The ‘fermented porridge’ of the straw beer was placed in the kitchen where the temperature was warmer, allowing the yeasts to grow well.

Alcoholic beverage production has many steps in common with non-alcoholic beverage (*togwa*) production (9). In the village, it was observed that non-alcoholic beverages were produced as a by-product in the course of the alcoholic beverage production. Since alcoholic beverage production consists of two different steps (i.e.

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saccharification and fermentation), while non-alcoholic beverage production needs only the saccharification step, alcoholic beverage production is more complicated than non-alcoholic beverage production. To some extent, the production of alcoholic beverages seems to derive from non-alcoholic beverages. Additionally, non-alcoholic beverages might be derived from a thin porridge (*uji*), while stiff porridge (*ugali*), which is a staple food, is produced from the same materials as the thin porridge. Based on these observations, we have described a food processing structure using the cereal of the staple crop named the '*ugali–uji–togwa–pombe* pathway'.

In the village, a self-sufficient food habit still exists, and available food materials are limited. For this reason, limited food materials need to be processed into various products. The cereal of the staple crop is the most available food material in the village. Therefore, the '*ugali-uji-togwa-pombe* pathway' using cereals has been developed to provide different tastes, nutrients and other food functions. However, it is still unknown why the '*ugali–uji–togwa–pombe* pathway' was developed. Interestingly, the production technique of non-alcoholic and alcoholic beverages is too complicated to have been developed spontaneously. Therefore, there must be specific reasons and particular processes for the development of the '*ugali–uji–togwa–pombe* pathway' that should be clarified with additional studies.

Conclusions

In the village, three different kinds of alcoholic beverages were produced: turbid beer, straw beer and hybrid straw beer. In the production of these alcoholic beverages, two different kinds of porridge (i.e. 'fermented porridge' and 'sweet porridge') were first manufactured, and then mixed at the end of the production process. This technique was effective in preventing contamination by harmful bacteria of the alcoholic beverages. Moreover, germinated finger millet, which has a high amylase activity, was used as an amylase source for the saccharification of starch, and the saccharification step was carried out in the range of optimal temperatures for the action of amylases. The fermentation step was also conducted at the optimal temperature for the growth of the yeast. The production technique of alcoholic beverages in the village appears to be sophisticated, and the food processing structure using the cereal of a staple crop, called the *ugali–uji–togwa–pombe* pathway, plays an important role in the food habit of the villagers.

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Captions

Figure 1. Method for the production of the turbid beer.

Figure 2. Changes in the temperature of (●) the 'fermented porridge' and the (○)'sweet porridge' during the production of (A) the turbid beer, (B) the straw beer and (C) the hybrid straw beer.

Figure 3. Changes in (A) glucose concentration (B) lactic acid concentration (C) pH during the production of (●) the turbid beer (▲), the straw beer and (■) the hybrid straw beer.

Figure 4. Method used for the production of the straw beer.

Figure 5. Method used for of the production of the hybrid straw beer.

Figure A1. Villagers drinking the straw beer using a long straw.

Figure A2. Villager pulverising the flour of germinated finger millet.

Figure A3. Example of a typical clay pot used for indigenous alcoholic beverage production.

Table 1. The pH and concentration of ethanol, glucose and lactic acid of (A) turbid beer, (B) straw beer and (C) hybrid straw beer

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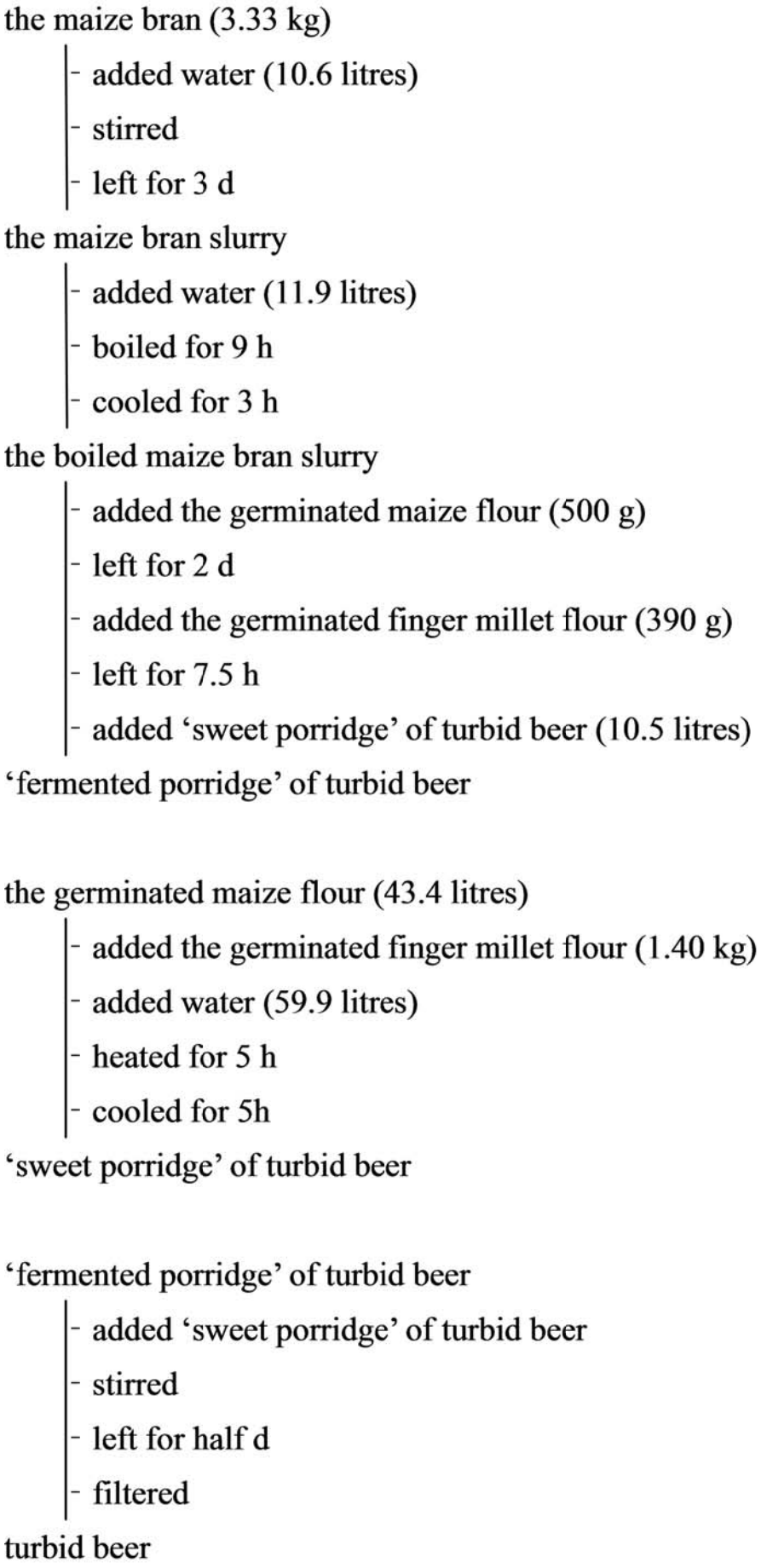

Figure 1

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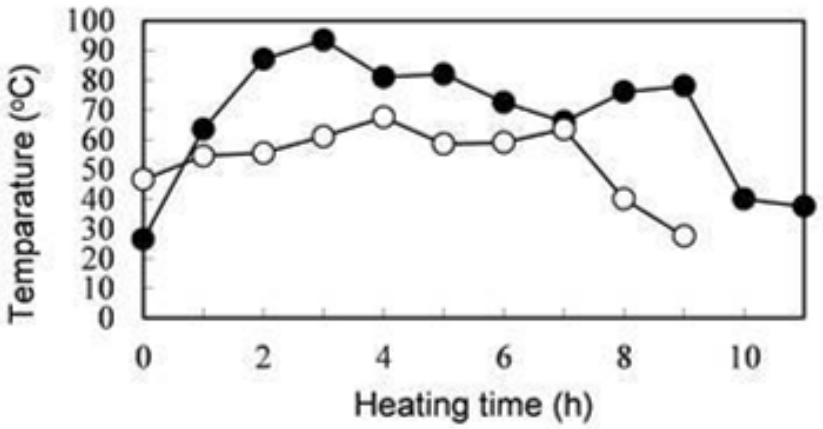

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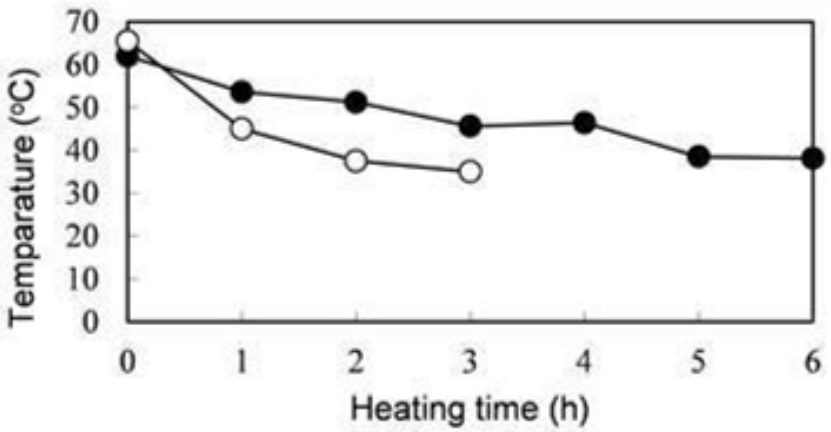

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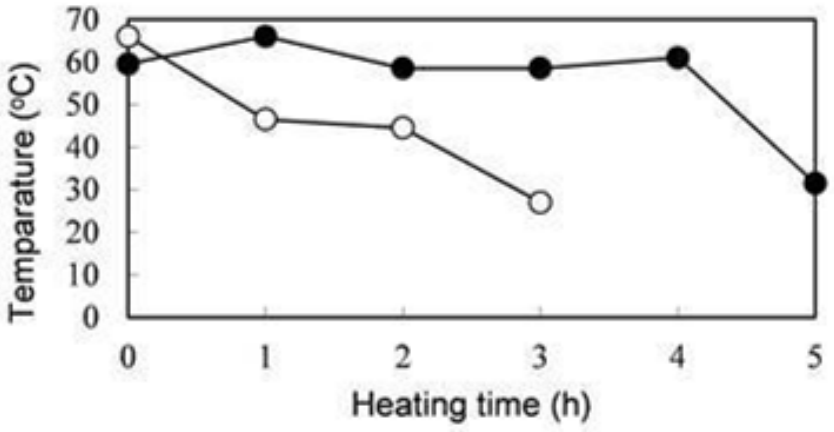

Figure 2

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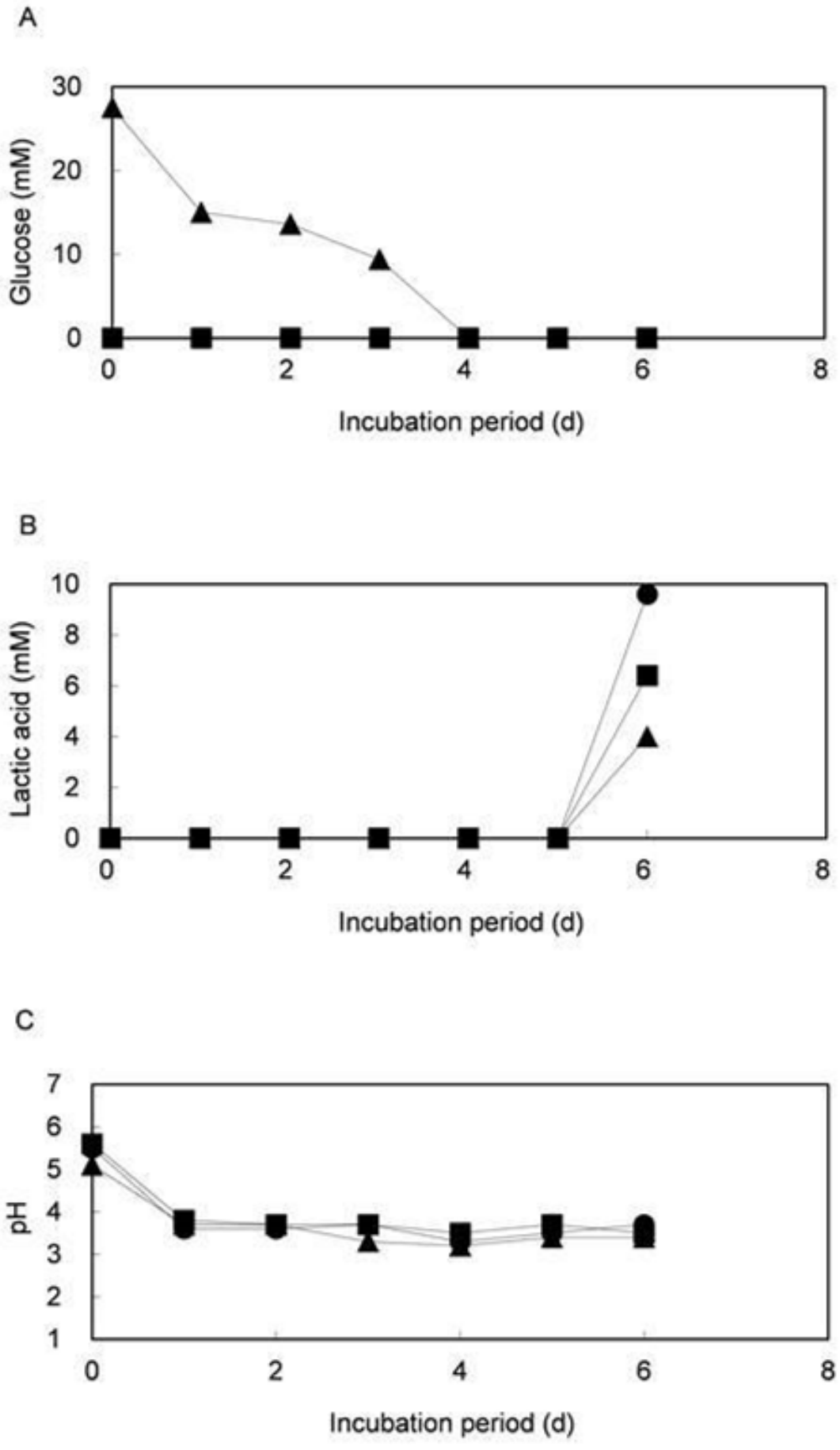

Figure 3

the germinated finger millet flour (352 g)

- added boiling water (4.91 litres, 96°C)
- stirred
- cooled for 6 h
- left for 6 d

'fermented porridge' of straw beer

the germinated finger millet flour (1.55 kg)

- added boiling water (10.5 litres, 88°C)
- stirred
- cooled for 3 h

'sweet porridge' of straw beer

'fermented porridge' of straw beer

- added 'sweet porridge' of straw beer
- added water (4.45 litres)
- stirred
- left for 1 d

straw beer

Figure 4

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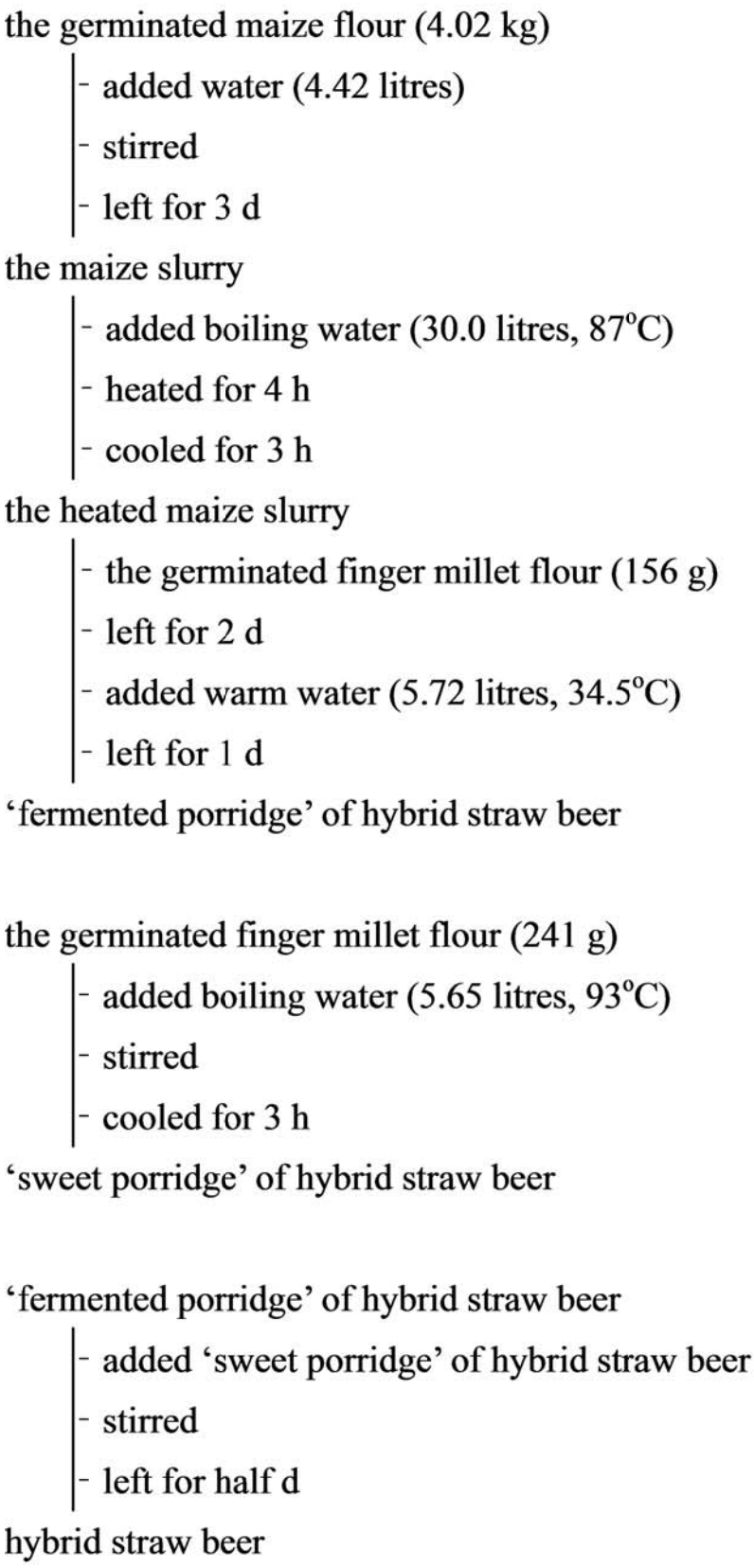

Figure 5

Figure A1

Figure A2

Figure A3

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A Turbid beer

	pH	ethanol (%)	glucose (mM)	lactic acid (mM)
'fermented porridge'	3.7	3.07	<1.10	9.60
'sweet porridge'	5.0	-	59.4	<0.80
turbid beer	4.0	12.8	<1.10	2.60

B Straw beer

	pH	ethanol (%)	glucose (mM)	lactic acid (mM)
'fermented porridge'	3.4	3.96	<1.10	4.00
'sweet porridge'	4.3	-	85.5	<0.80
straw beer	3.8	15.5	<1.10	15.2

C Hybrid straw beer

	pH	ethanol (%)	glucose (mM)	lactic acid (mM)
'fermented porridge'	3.5	7.47	<1.10	6.40
'sweet porridge'	5.7	-	29.3	<0.80
hybrid straw beer	3.7	11.4	<1.10	7.20

Table 1